Early Student Support for Shipboard LADCP/χpod Profiling of Internal Wave Structure and Dissipation in the Luzon Strait

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LONG-TERM GOALS

We seek a more complete and fundamental understanding of the hierarchy of processes which transfer energy and momentum from large scales, feed the internal wavefield, and ultimately dissipate through turbulence. This cascade impacts the acoustic, optical, and biogeochemical properties of the water column, and feeds back to alter the larger scale circulation. Studies within the **Ocean Mixing Group** at OSU emphasize observations, innovative sensor / instrumentation development and integration, and process-oriented internal wave and turbulence modeling for interpretation.

OBJECTIVES

Luzon Strait represents a major source of internal tides and NLIWs in the SCS. However, unlike other regions of strong internal wave generation (i.e., Hawaii), Luzon Strait is believed to be highly dissipative. We seek to understand the character of this enhanced nonlinearity and turbulence, and how it affects internal wave generation and transmission. Specifically, we intend to:

- identify hotspots of generation and dissipation,
- quantify the structure and variability of wave energy, its flux and dissipation at the generation site.
- link the broader spatial structure, temporal content, and energetics of the internal wave field to the topography, forcing, and mesoscale influences (i.e., Kuroshio).

APPROACH

Much of the turbulent dissipation in Luzon Strait was anticipated to be deep, outside the range of tethered microstructure profilers, and evolving too rapidly for autonomous profilers. We have used a 2-fold approach to quantify this deep turbulence:

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1. rapid profiles at abyssal depths are obtained using standard shipboard CTD, augmented with ADCPs, turbulence sensors, and a motion package. These allow us to systematically obtain 36-h yo-yo timeseries, from which energy generation, energy fluxes, and energy dissipation can be directly measured.
2. Five moorings were successfully deployed and recovered in 2 of the most energetic regions of the strait. Recovery cruises were mid Aug and early Sept, 2011, so these data are just starting to be analyzed.

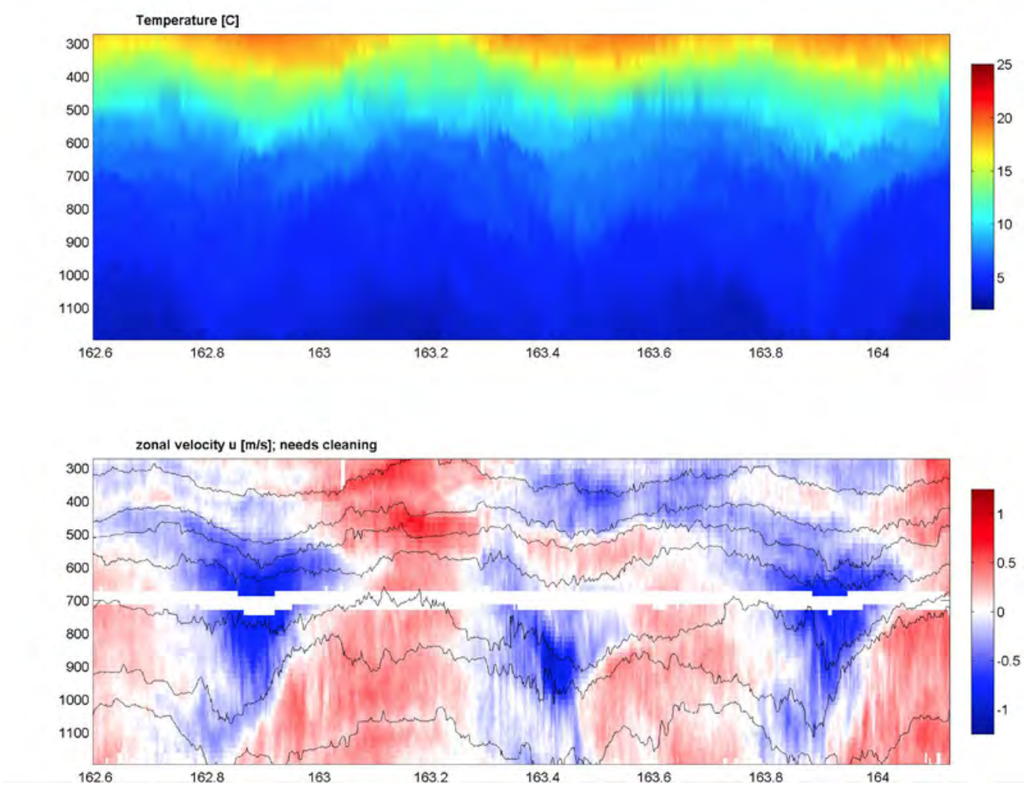

Figure 1: An example 1.5-day record of T (top) and velocity (bottom; with T contoured) from the stablemoor mooring. Time is in yeardays (2011); depth in m. Peak flows and displacements exceed 1 m/s and 300 m.

WORK COMPLETED

This award has so far provided 4 months of support for graduate student Byungho Lim. Byungho helped with instrument preparations for this summer's fieldwork and participated in two of the IWISE cruises this past summer. He is currently continuing coursework to fulfill requirements of the OSU Physical Oceanography program.

Byungho will be involved in the analysis of moored and shipboard data collected this summer. Examples of these data (from instruments recovered in Aug and Sept 2011) are shown in figures 1 and 2. These focus on 2 aspects of the flow: (1) the radiated energy and local dissipation at a site of strong wave generation (the Stablemoor mooring; figure 1), and (2) the structure of wave and dissipation events on the western ridge near station N2. At that site, 5 moorings were deployed at 1-km spacing to capture the evolution of billowing as the waves break at the ridge crest (figure 2).

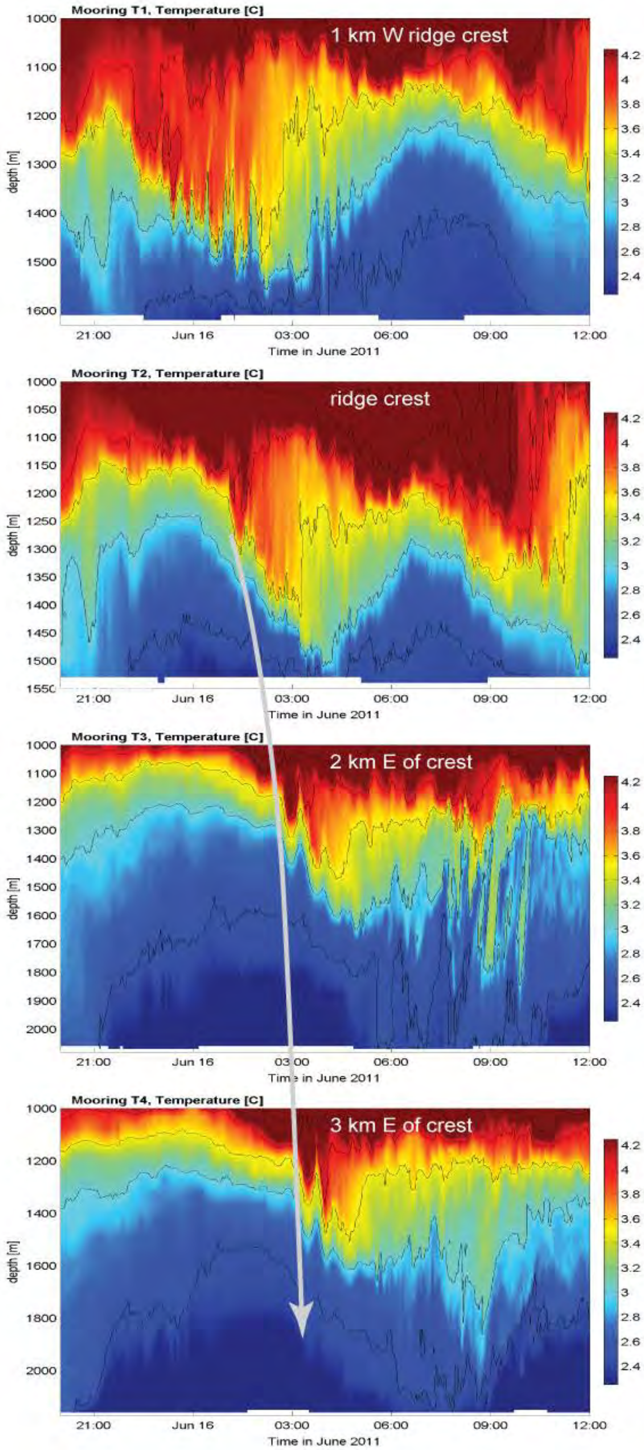

Figure 2: The figure at right shows a 16 h segment of temperature data from the 4 T-chains deployed over the ridge near N2. These moorings were spaced 1 km apart and capture displacements and turbulence in x,z,t space. The depictions at right rival numerical simulations in resolution but capture the represent the true reality and breadth of scales of the real ocean. These figures show the evolution and spatial structure of a 300-m tall wave which grows to 500 m and breaks. Short-wavelength features are coherent across the mooring array and can be tracked (grey arrow). 100-500 m tall turbulent overturns are also visible, particularly at mooring T3 at 0900.

This example represents one 16-h time window within the 3-month deployment. Our objectives are to analyze these records in detail in order to quantify both internal wave and turbulent components. We will combine data from LADCP/χpod, MP-χpods, the moorings shown here, the stablemoor (at A1) and other ancillary moored and model data in these analyses. Ultimately, we will

1. characterize the spatial and temporal variability of high-dissipation events
2. determine the physics of high-wavenumber generation from the surface and internal tides, and the subsequent breakdown into turbulence
3. assess how these dynamics are related to those which have been numerically modeled, with a goal of understanding whether these can be parameterized.

RELATED PROJECTS

Profiling and moored operations are being coordinated with M Alford (UW); analysis of turbulence data are being conducted in conjunction with J MacKinnon (UCSD), H Simmons (UAF) and L. St. Laurent (WHOI). Data/model integration and comparisons will be made with Simmons, Klymak, and Buijsman.

REFERENCES

Klymak, J.M., J.N. Moum, J.D. Nash, E. Kunze, J.B. Girton, G.S. Carter, C.M. Lee, T.B. Sanford, and M.C. Gregg, 2006: An estimate of tidal energy lost to turbulence at the Hawaiian Ridge. *J. Phys. Oceanogr.*, 36, 1148-1164.

Moum, J.N. and J.D. Nash, 2009: Mixing measurements on an equatorial ocean mooring, *J. Atmos. and Oceanic Tech.*, 26, 317-336.

Nash, J.D., E. Kunze, C.M. Lee and T.B. Sanford, 2006: Structure of the baroclinic tide generated at Kaena Ridge, Hawaii, *J. Phys. Oceanogr.*, 36(6), 1123-1135.